

REMARKS

Claims 1-31, 52, and 54-59 pending in the application with claims 1-4, 6-8, 10, 20-22, 52, 54, and 55 amended herein, new claims 56-59 added herein, and claim 53 canceled herein.

Claims 52 and 54 stand rejected under 35 U.S.C. 102(e) as being anticipated by Bai. Applicants request reconsideration.

Amended claim 52 sets forth a method of forming a dielectric layer that includes, among other features, forming a first metal-containing dielectric layer over a silicon-containing surface of a substrate, the metal of the first layer consisting essentially of hafnium, and forming a second metal-containing dielectric layer on the first metal-containing dielectric layer, the metal of the second dielectric layer consisting essentially of lanthanum. Pages 2-3 of the Office Action allege that Bai discloses every element of claim 52, however, Bai does not disclose or suggest every element of amended claim 52.

Specifically, amended claim 52 sets forth that the metal of the first layer consists essentially of hafnium and that the second metal-containing dielectric layer is formed on the first metal-containing dielectric layer. The Office Action equates the first metal-containing dielectric layer with bottom dielectric layer 130 of Bai that may include hafnium oxide. The Office Action also equates the second metal-containing dielectric layer with the third dielectric layer of Bai. The third dielectric layer may include lanthanum oxide. However, Bai does not disclose or suggest the third dielectric layer on bottom dielectric layer 130. Bai requires the presence of top dielectric layer 120 between bottom dielectric layer 130 and the third dielectric layer.

Paragraph [0027] of Bai states that the third dielectric layer is a barrier layer used to prevent interaction between the materials of top dielectric layer 120 and polysilicon gate material. If top dielectric layer 120 is removed, then no need exists for the third dielectric layer. Bai states that the third dielectric layer is "the same materials suitable as bottom dielectric layer 130." Thus, if top dielectric layer 120 is removed, then Bai does not provide any suggestion to add the third dielectric layer or describe any possible benefit of such layer. Bai cannot be considered to disclose the third dielectric layer on bottom dielectric layer 130. Accordingly, Bai does not disclose the second metal-containing dielectric layer of claim 52.

Applicants note that the term "on" has a different meaning from the term "over." Merely disclosing a certain layer "over" another layer, does not constitute disclosure or suggestion of the certain layer "on" the another layer. Such case is especially true of Bai where top dielectric layer 120 is required between bottom dielectric layer 130 and the third dielectric layer.

Anticipation requires disclosure of each and every claim element. Applicants assert that Bai fails to anticipate claim 52 and further asserts that Bai fails to disclose or suggest the subject matter of claim 52.

Amended claim 54 sets forth a method for forming a MOS transistor that includes, among other features, forming a dielectric layer consisting of hafnium oxide overlying a surface of a semiconductor substrate, forming a dielectric layer consisting of lanthanum oxide on the hafnium oxide dielectric layer, and forming a gate electrode over the hafnium oxide and lanthanum oxide dielectric layers. Pages 2-3 of the Office Action allege that Bai

discloses the subject matter of claim 54, however, Bai does not disclose amended claim 54.

It can readily appreciated from the discussion above regarding claim 52 that Bai fails to disclose a lanthanum oxide dielectric layer on a hafnium oxide dielectric layer. Regardless of their potential compositions, the third dielectric layer of Bai is not disclosed as being on bottom dielectric layer 130 of Bai. Accordingly, Bai fails to disclose each and every element of claim 54 and thus does not anticipate claim 54. Applicants assert that Bai further does not suggest the subject matter of claim 54.

At least for the reasons described above, Applicants assert that Bai does not anticipate claim 52 and 54. Applicants request allowance of such claims in the next Office Action.

Claims 1-7 and 19 stand rejected under 35 U.S.C. 102(a) as being unpatentable over by Bai in further view of Kaushik. Applicants request reconsideration.

Amended claim 1 sets forth a method of forming a dielectric layer that includes, among other features, forming a first metal-containing dielectric layer over a silicon-containing surface of a substrate, the metal of the first layer consisting of at least one element selected from the Group IVB and forming a second metal-containing dielectric layer on the first metal-containing dielectric layer, the metal of the second dielectric layer consisting of at least one element selected from Group IIIB. Pages 3-4 of the Office Action allege that Bai discloses every element of claim 1 except for forming a silicon dioxide layer and relies on Kaushik for such disclosure. However, the silicon dioxide layer subject matter

has been removed from claim 1. Further review reveals that Bai does not disclose or suggest every element of amended claim 1.

Specifically, amended claim 1 sets forth that the metal of the first layer consists of at least one element selected from Group IVB. Accordingly, the only metals comprised by the first metal-containing dielectric layer are Group IVB metals, and one or more of such metals may be included. Also, claim 1 states that the second metal-containing dielectric layer is formed on the first metal-containing dielectric layer. The Office Action equates the first metal-containing dielectric layer with bottom dielectric layer 130 of Bai that may include hafnium oxide or zirconium oxide with Group IVB metals. The Office Action also equates the second metal-containing dielectric layer with the third dielectric layer of Bai used as a barrier layer. The third dielectric layer may include  $\text{La}_2\text{O}_3$  or  $\text{Y}_2\text{O}_3$  with Group IIIB metals. However, Bai does not disclose or suggest the third dielectric layer on bottom dielectric layer 130. Bai requires the presence of top dielectric layer 120 between bottom dielectric layer 130 and the third dielectric layer, as discussed above with regard to claim 52. Accordingly, the third dielectric layer of Bai does not disclose a second metal-containing dielectric layer of claim 1.

*argue*

Further, Paragraph [0019] of Bai lists several elements that may be comprised by top dielectric layer 120 including titanium and zirconium of Group IVB. However, the only examples of top dielectric layer 120 materials are BST and PZT. Neither of the exemplary materials meets the requirement of claim 1 that the metal of the first metal-containing dielectric layer consists of at least one element selected from Group IVB. Instead, BST and PZT both include metals that are not selected from Group IVB. Accordingly, top

*argu*  
dielectric layer 120 does not disclose or suggest the first metal-containing dielectric layer of  
claim 1.

Obviousness requires disclosure or suggestion of every claim element. Applicants assert that Bai fails to disclose or suggest the subject matter of claim 1. Kaushik does not disclose or suggest and is not alleged to disclose or suggest the subject matter missing from amended claim 1. Thus, combination of the references still does not establish obviousness. Claims 2-7 and 19 depend from claim 1 and are patentable at least for such reason as well as for the additional limitations of such claims not disclosed or suggested. Applicants request allowance of claims 1-7 and 19 in the next Office Action.

Claims 8, 9, 13-15, 16, 18, 20-24, 26, 27, 29-31, 53, and 55 stand rejected under 35 U.S.C. 103(a) as being unpatentable over by Bai and Kaushik in further view of Zhang. Claim 53 is canceled herein. Applicants request reconsideration of the remaining claims.

Claims 8, 9, 13-15, 16, and 18 depend from claim 1 the subject matter of which is discussed above. As also discussed above, the combination of Bai and Kaushik does not disclose or suggest the subject matter of amended claim 1. Zhang does not disclose or suggest and is not alleged to disclose or suggest the subject matter absent from Bai and Kaushik. Accordingly, combination of the three references cannot be considered to disclose or suggest every element of claim 1. Claims 8, 9, 13-15, 16, and 18 are thus patentable at least for such reason as well as for the additional limitation of such claims not disclosed or suggested.

Amended claim 20 sets forth a method for forming a MOS transistor including, among other features, forming a hafnium-containing dielectric layer overlying a surface of a

semiconductor substrate, forming a lanthanum-containing dielectric layer on the hafnium-containing dielectric layer, and forming a gate electrode over the hafnium-containing and lanthanum-containing dielectric layers. It can be readily appreciated from the discussion above regarding claim 1 that Bai fails to disclose or suggest a lanthanum-containing dielectric layer on a hafnium-containing dielectric layer. Additionally, neither Kaushik nor Zhang disclose or suggest such a feature.

Pages 7-8 of the Office Action allege that Bai discloses the third dielectric layer on a hafnium-containing dielectric layer. However, the only hafnium-containing dielectric layer of Bai is bottom dielectric layer 130 and Bai does not disclose or suggest the third dielectric layer on bottom dielectric layer 130. Applicants note the above assertions regarding the deficiencies of Bai. Accordingly, Bai fails to disclose or suggest every element of claim 20. Kaushik and Zhang are similarly deficient so claim 20 is patentable over the cited combination.

Applicants also note that amended claim 20 reads identically to previous claim 54. Any new ground of rejection for amended claim 20 must be presented in a non-final Office Action since previous claim 54 was insufficiently rejected as being anticipated by Bai.

Claims 21-24, 26, 27, and 29-31 depend from claim 20 and are patentable at least for such reason as well as for the additional limitations of such claims not disclosed or suggested.

Amended claim 55 sets forth a method for forming a MOS transistor that includes, among features, forming a hafnium-containing layer overlying a surface of a semiconductor substrate, oxidizing the hafnium-containing layer into a hafnium-containing dielectric layer,

*arguer* forming a lanthanum-containing dielectric layer on the hafnium-containing dielectric layer and forming a gate electrode over the hafnium-containing and lanthanum-containing dielectric layers. As can readily appreciated from the assertions herein, none of the cited references disclose or suggest the subject matter of amended claim 55.

Applicants herein set forth adequate reasons to establish patentability of claims 8, 9, 13-15, 16, 18, 20-24, 26, 27, 29-31, and 55 and request allowance of all such claims in the next Office Action.

Pages 10-11 of the Office Action state that claims 10-12 and 28 would be allowable if rewritten in independent form including all the limitations of the base claim and any intervening claims. New claims 56-59 are set forth herein as constituting allowable claims 10-12 and 28 rewritten in independent form as required. Applicants request allowance of new claims 56-59 in the next Office Action.

The Office Action Summary page states that claims 17 and 25 are rejected, but the Detailed Action portion of the Office Action does not anywhere list claims 17 or 25 as rejected. Thus, the Office Action further does not provide any basis supporting rejection of claims 17 and 25. In the absence of such adequate basis, claims 17 and 25 are considered to be allowable. Applicants request clarification.

Applicants respectfully traverse the Response to Arguments on pages 11-12 of the Office Action with respect to claim 20 as being inaccurate. However, in view of the amendment to claim 20 herein, such traverse is now moot.

Applicants herein establish adequate reasons for allowance of claims 1-31, 52, and 54-59. Applicants request allowance of all pending claims in the next Office Action.

Respectfully submitted,

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Title: A Dielectric Layer Forming Method and Devices Formed Therewith

VERSION WITH MARKINGS TO SHOW CHANGES MADE ACCOMPANYING  
RESPONSE TO JULY 26, 2002 OFFICE ACTION

In the Claims

The claims have been amended as follows. Underlines indicate insertions and ~~strikeouts~~ indicate deletions.

1. (twice amended) A method of forming a dielectric layer comprising:  
providing a substrate comprising a silicon-containing surface;  
~~forming a layer of silicon dioxide overlying at least one portion of the surface;~~  
~~forming a metal layer over the layer of silicon dioxide; combining metal of the~~  
~~metal layer with oxygen of the silicon dioxide layer to form a metal oxide as forming~~ a  
first metal-containing dielectric layer over the surface, the metal comprising an of the  
first dielectric layer consisting of at least one element selected from Group IVB of the  
periodic table; and  
forming a second metal-containing dielectric layer over on the first metal-  
containing dielectric layer, the metal of the second dielectric layer consisting of at least  
one element selected from Group IIIB of the periodic table.

2. (amended) The method of Claim 1, wherein the metal of the first metal-containing dielectric layer comprises consists of hafnium.
3. (twice amended) The method of Claim 1, ~~wherein the second metal-containing dielectric layer is formed on the first metal-containing dielectric layer further comprising:~~ forming a layer of silicon dioxide overlying at least one portion of the surface; and wherein forming the first metal-containing dielectric layer comprises:  
forming a metal layer over the layer of silicon dioxide; and  
combining metal of the metal layer with oxygen of the silicon dioxide layer  
to form a metal oxide dielectric material.
4. (twice amended) The method of Claim 4 3, wherein the metal layer comprises hafnium.
6. (amended) The method of Claim 1, where the metal of the second metal-containing dielectric layer comprises an consists of one element selected from Group IIIB of the periodic table.
7. (amended) The method of Claim 1, where the metal of the second metal-containing dielectric layer comprises consists of lanthanum.

8. (twice amended) The method of Claim 1, where the metal layer comprises a hafnium-containing layer and the forming of the first metal-containing dielectric layer and the forming of second metal-containing dielectric layer comprise comprises:

forming a hafnium-containing layer;

forming a lanthanum-containing layer over the hafnium-containing layer; and

exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

10. (twice amended) The method of Claim 8, where the exposing comprises ion bombardment of the first hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 electron volts (eV) or less.

20. (twice amended) A method for forming a MOS transistor, comprising:

providing a semiconductor substrate having a surface comprising silicon;

forming a hafnium-containing dielectric layer overlying the surface, including first forming a hafnium-containing layer;

forming a lanthanum-containing dielectric layer overlying on the hafnium-containing dielectric layer, including second forming a lanthanum-containing layer, the first forming and the second forming encompassing physical vapor deposition; and

forming a gate electrode over the hafnium-containing and lanthanum-containing dielectric layers.

21. (twice amended) The method of Claim 20, wherein the lanthanum-containing dielectric layer is formed on the hafnium-containing dielectric layer where:

the forming of the hafnium-containing dielectric layer dielectric layer comprises first forming a hafnium-containing layer;

the forming of the lanthanum-containing dielectric layer comprises second forming a lanthanum-containing layer; and

wherein the first forming and the second forming encompass physical vapor deposition.

22. (twice amended) The method of Claim 20 21, where physical vapor deposition comprises electron beam evaporation.

52. (amended) A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;

forming a first metal-containing dielectric layer over the surface, the metal of the first layer comprising an element selected from Group IVB of the periodic table

consisting essentially of hafnium; and

forming a second metal-containing dielectric layer on the first metal-containing dielectric layer, the metal of the second layer comprising an element selected from Group IIIB of the periodic table consisting essentially of lanthanum.

54. (amended) A method for forming an MOS transistor, comprising:
- providing a semiconductor substrate having a surface comprising silicon;
- forming a hafnium-containing dielectric layer consisting of hafnium oxide overlying the surface;
- forming a lanthanum-containing dielectric layer consisting of lanthanum oxide on the hafnium-containing hafnium oxide dielectric layer; and
- forming a gate electrode over the hafnium-containing hafnium oxide and lanthanum-containing lanthanum oxide dielectric layers.
55. (amended) A method for forming an MOS transistor, comprising:
- providing a semiconductor substrate having a surface comprising silicon;
- forming a hafnium-containing layer overlying the surface;
- oxidizing the hafnium-containing layer into a hafnium-containing dielectric layer;
- forming a lanthanum-containing dielectric layer overlying on the hafnium-containing dielectric layer; and
- forming a gate electrode over the hafnium-containing and lanthanum-containing dielectric layers.

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